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PALESTINE REFUGEE PROBLEM

Tentative Plan for the Full Development of Irrigation and Allied Subjects in Iraq

by F. F. Haigh, President, Irrigation Development Commission

Introductory. Although the investigations of the Irrigation Development Commission are at present by no means complete, they have now progressed sufficiently for a tentative general plan for the control and full development of the water resources of the country to be suggested. Some such plan is required in order that such development as is proposed in the near future may be designed to conform to the final development and expenditure on works which may not ultimately be required may be avoided. An approximate estimate of the total cost and the cost of the various types of works involved is also required, in order that it may be compared with the resulting benefits, and methods of financing the development evolved. As regards the finality of the plan, alternative methods of supplementing the supplies of the Lesser Zab and the Diala are still under investigation and it is possible that one of these might turn out to be preferable to the Dokan or Gibraltar Dam. It has also to be established yet that the salt contents of the Abu Dibis and Bahr al Milh can be successfully dealt with, and if not, some alternative for final stage storage on the Euphrates will require to be found. Apart from these alternatives no major change in the form of the plan is ultimately probable, though much of the detail of the later stages remain to be worked out. As regards the accuracy of the estimates, the cost of the major flood control schemes i.e. the Habbaniyah, the Wadi Tharthar and the Gibraltar Dam is based on detailed designs and estimates, and can consequently be relied upon. The estimates of the various barrages and feeders required in connection with distribution, of the Dokan Dam, of the Abu Dibis Project and of power development are based on outline designs only but should be fairly correct. The cost of distribution and drainage, however, is based on average rates for which inadequate data is available, and the resulting figures must, therefore, be considered to be approximations only.

The plan covers the following subjects and it will be convenient to deal with each in turn:

(a) Flood Control and Storage.
(b) Irrigation Development.
(c) Drainage.
(d) Hydro-electric Power.
(e) Navigation.

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Flood Control and Storage. This can conveniently be dealt with by the rivers concerned.

(a) The Euphrates

The Commission has considered the various possibilities of flood control on this river and is in agreement with Government's previous advisers that the best method of dealing with the problem is the Habbaniyah Project. The only alternatives would be high dams in the upper reaches of the river, and investigations of similar works on the Tigris have shown that their cost would far exceed that of the Habbaniyah Project in proportion to the results achieved. The Commission were able to suggest improvements in the Projects and have prepared detailed designs and estimates of the works concerned from which it appears that the cost will be as below:

Habbaniyah Project Stage I	ID 2,700,000
Habbaniyah Project Stage II	675,000

The Habbaniyah reservoir will have a storage capacity of 3.3 milliards gross of 2.3 live. It will control the Euphrates to 2,000 cumecs and will provide water for the extension of irrigation to 3,300,000 mesharas gross.

Additional flood control and storage on the Euphrates can be provided by the use of the Abu Dibis and Bahr al Milh depressions. The cost of this Project has not yet been estimated in detail; but a preliminary investigation indicates that its cost would be about ID 2,000,000. The reservoir thus formed will have a very large capacity, about 21 milliards gross or 17 live. It will be used for perennial or over year storage and will enable the flood control to be improved to 1500 cumecs and for irrigation extensions to an additional 1,200,000 mesharas or 4,500,000 mesharas in all.

The total cost of flood control and storage on the Euphrates would thus be ID 5,375,000.

(b) The Tigris

The Commission has investigated in detail the following schemes for flood control and storage on the Tigris and its tributaries.

(I) The Fatha Dam

This project comprises an earthen dam across the main Tigris at the Jebel Hamrin and would provide a very large reservoir with a capacity of 24 milliards gross or 20 live. Assuming a geological investigation to give satisfactory results its cost is estimated at ID 20,000,000.

(II) The Wadi Tharthar Project

This makes use of the natural Wadi Tharthar Depression, and comprises a barrage across the Tigris at Samarra with long inlet and outlet channels. The capacity is 70 milliards gross of which 24 milliards would be used for storage. Its cost is estimated at ID 14,500,000. It is capable of development by stages.

(III) The Bekhme Dam Project

This comprises a dam on the upper reaches of the Greater Zab river. Several alternative schemes have been worked out by the Commission of which the most favorable is a rock-fill dam about 100 m. in height at a cost of ID 12,000,000. This would provide a reservoir of 3.5 milliards gross capacity; 3.0 milliards live.

(IV) A Diala Dam

The Commission has investigated in detail projects for concrete and rock-fill dams at Derbank-i-Khan on the Upper Diala. Also a Project for a gravel fill dam at the Gibraltar site in the Jebel Hamrin. Of these the most favorable is the last which will provide a reservoir of 2.3 milliards gross capacity at a cost of ID 2,500,000.

(V) Dokan Dam

On the Lesser Zab the Commission has considered the Derbank-i-Rania, Torjo and Dokan dam sites, and has concluded that the last is the most favorable. A detailed design for a dam at this site is now under preparation and it is believed that this will provide a reservoir of about 2 milliards capacity at a cost of about ID 4,000,000.

It is desirable to control the Tigris to about 3500 cumecs maximum discharge, and for this and to make a large proportion of Tigris water available for irrigation, a large storage capacity, not less than 20 milliards, is required, which can only be obtained at the Fatha or Wadi Tharthar sites. Of these Projects the Wadi Tharthar is the more economical in proportion to results, and its construction has consequently been recommended to Government. It will provide flood control to 3500 cumecs of the Tigris including Diala supplies except on rare occasions, and storage water for extensions of irrigation to 10,000,000 mesharas gross.

The Wadi Tharthar Project will be capable of storing directly all Lesser Zab Water. It will also by virtual storage enable full use to be made of Diala water. The Dokan and Gibraltar reservoirs would increase somewhat the gross storage available and hence permit additional supplies to be stored, but this would be counterbalanced by an increase in evaporation losses and on the whole

would not be advantageous. From the point of view of flood control, however, these reservoirs would be distinctly useful. It has been said above that the Wadi Tharthar would provide control to 3500 cumecs except on rare occasions. These occasions would be when the total discharge of the river exceeds 14,000 cumecs or when the combined Diala and Adhaim discharges, which cannot be controlled by the Wadi Tharthar, exceed 3500 cumecs. Each of these tributary (lesser Zab and Diala) reservoirs could be used to absorb the peaks of occasional very high floods and as such would each be equivalent to increasing the capacity of the Wadi Tharthar inlet channel by about 2500 cumecs. An increase in the channel capacity of 5000 cumecs would cost about ID 2,500,000 and would not be effective in the case of high supplies in the Diala. Other uses of these reservoirs will be dealt with in the next section.

IRRIGATION DEVELOPMENT.

The works required for the development of irrigation in new areas comprise the provision of canals and their appertinent works, and of barrages and feeders required to command the canals. In the absence of detailed designs for the distribution works, their cost can be estimated on the basis of the gross area served. The Commission has worked out distribution details in one case only to date, that of the Hillah canal remodelling where the cost is approximately ID 2.4 per mesharа gross. It is thought that this rate is rather high, the conditions in this case being more difficult than average, and it is proposed to adopt a rate of ID 2.00 for general use in this Note. The barrage, feeder etc., required will be dealt with by extension districts.

(a) Euphrates Extensions.

The area involved is 4,500,000 mesharas gross and for this a general scheme of development has been worked out. The area consists of two parts, the desert area lying between the Hillah canal and the Tigris known as the Jezirah to the north, and the area of swamp and desert between the Euphrates and the Gharraf to the south through which runs the old Euphrates channel known as the Shatt-al-Khar. The upper part of the Jezirah area will be served by a considerable enlargement of the existing Musayib Canal, and the lower part by extensions from the Hillah, and the cost of these works should be covered by the average rate. For the Shatt-al-Khar area, however, it will be necessary to have a large feeder from the Euphrates near Kifl to the Diwaniyah canal and to construct a barrage at Kifl to command it.

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The cost of these extensions is estimated as below:

4,500,000 mesharas gross @ ID 2	ID 9,000,000
Kifl Barrage	500,000
Diwaniyah Feeder	1,000,000
Total	ID 10,500,000

The overall cost of development in these areas is thus ID 2.34 per meshara gross.

(b) Lesser Zab Extensions.

These comprise areas on both banks of the Lesser Zab below Altun Keupri, the area on the Tigris left bank between Fatha and the Adhaim and areas on both banks of the Adhaim below the Jebel Hamrin totalling 1,600,000 mesharas. For the command of these areas it is essential to have a barrage across the Lesser Zab, a feeder to the Adhaim and a barrage on the latter river. The natural flow of the Lesser Zab is not sufficient for all the area involved and consequently it will require to be supplemented if the whole is to be irrigated.

(i) A feeder from the Greater Zab,
(ii) The Dokan Dam, and
(iii) a Dam at Damir on the Adhaim to form a reservoir in which Lesser Zab water brought across by the feeder could be stored.

These alternatives are at present under detailed investigation but it seems probable that in view of its value in flood control, the Dokan Dam may be preferred. Apart from the dam the cost of these extensions would be approximately:

1,600,000 mesharas gross @ ID 2	ID 3,200,000
Lesser Zab Barrage	400,000
Fils Feeder	160,000
Adhaim Barrage	250,000
Total	ID 4,010,000

or ID 2.50 per meshara gross.

If half the cost of the Dam is debited to these extensions the cost would be raised to ID 3.75 per meshara. Extension to these areas will be more expensive than in others, but the land is believed to be of good quality, and likely to be very productive. The areas are also centrally situated.

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(c) The Is-haqi Area.

This is a small area situated on the Right bank of the Tigris between Samarrah and Daudiyah. It will be commanded by the Samarrah barrage. There are no particular difficulties about its irrigation and the cost will be

500,000 mesharas @ ID 2.00 ID 1,000,000.

(d) Diala and Nahrwan Area.

This comprises supplementing the supply to 500,000 mesharas gross at present receiving inadequate water from the Diala Canals and extensions to 2,500,000 mesharas gross on the left bank of the Tigris between the Diala and Ku[illegible]. For the command of the Diala canal area it will be necessary to supply water above the existing Diala Weir or at an aqueduct or level crossing a short distance below it. For the command of the majority of the extension area a barrage will be required on the Diala in the vicinity of Cassell's and since the Diala supplies, even if stored, are quite inadequate for this large area, a feeder from the Tigris will be required with a barrage at or above Dukhela. Supplies for the higher areas can be obtained (1) by storage on the Diala, (2) by a high level Tigris feeder taking off from the Samarrah barrage, or (3) by a feeder from the Adhaim connecting with the Lesser Zab-Adhaim feeder. Without storage on one of the tributaries the natural flow of the Tigris and the Diala will be insufficient for the whole of the Lesser Zab and Nahrwan areas, and consequently for their full development a second barrage would be necessary across the Tigris below the Wadi Tharthar outlet at Daudiyah. These various alternatives are at present under investigation but it seems probable that in view of its value in flood control, Diala storage will be the best solution. In this case the cost will be approximately as below:

2,500,000 mesharas gross @ ID 2	ID 5,000,000
Tigris barrage	1,500,000
Nahrwan feeder	400,000
Diala barrage	450,000
	ID 7,350,000

As the supplies of 500,000 mesharas on the Diala canals will also be improved we might consider the area served as 2,750,000 mesharas and the cost per meshara ID 2.67. If half the cost of Diala storage is debited to these extensions the cost per meshara would be increased to ID 3.12.

(e) Lower Tigris Areas.

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After providing for existing irrigation and the extensions noted above the Tigris and its tributaries with storage fully developed will be able to provide irrigation for a further 5,500,000 mesharas gross and this it is proposed should be used in the Tigris riverain areas below Kut and in the area between the Gharraf and the Tigris down to the Hammar Lake. Details of the development have not yet been worked out but is known that the greater part of the area will be served from the Gharraf. This channel will consequently have to be canalized and provided with such cross-regulators as are necessary to command the canal distributary systems. The closest estimate of the cost which can be made at present is to apply a rate of say ID 2.5 to the gross area i.e. 5,500,000 mesharas @ ID 2.50 ID 13,750,000.

DRAINAGE. In Iraq, experience has shown that drainage is essential if the productivity of irrigated lands is to be maintained. Without it irrigated lands are liable to become saline or water-logged. In extreme cases the land goes entirely out of production in a few years. In other cases the yield is reduced to a greater or less extent, and hence also Government's revenue. It is strongly recommended, therefore, that all areas both of existing irrigation and new development should be provided with an adequate drainage system, the only exceptions being lift areas which are automatically provided with drainage by the channels from which they draw their supplies. The cost of drainage per unit of area, like the cost of canals, varies little in different irrigation schemes and it will suffice for the estimation of the cost of drainage to apply a rate to the known area. The Commission have worked out in detail several small drainage schemes and from these it would appear that a rate of ID 2.00 per meshara gross would be suitable. The gross area at present served by flow which is approximately equal to the lift area is 5,500,000 mesharas. The total cost of drainage may therefore be:

Old area 5,500,000 @ ID 2 per meshara		ID 11,000,000
New area 14,600,000 @ ID 2 per meshara		29,200,000
	Total	ID 40,200,000

The expenditure involved under this head is large but is justified by its effect in maintaining or increasing the productivity of the land and consequently revenue.

5) POWER. In the scheme of development proposed the development of hydro-electric power is possible at three sites: the Wadi

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Tharthar Outlet Channel, the Gibraltar dam and the Dokan dam. The quantity of power which can be produced at each site and the approximate cost is given below:

Sites	Power k.w.	Cost ID	Cost per k.w., ID
Wadi Tharthar	66,000	4,500,000	68
Gibraltar	15,000	1,350,000	90
Dokan	40,000	2,000,000	50
Total	121,000	7,850,000	65

Figures of costs include the power station, the generating plant, transmission to Baghdad in the case of the first two and for 50 miles in the case of Dokan, and delivery at 11,000 volts pressure. In the case of Dokan it is assumed that power would be used locally, possibly in the development of the mineral resources of the neighborhood. On the above figures it should be possible to deliver power at from 1.6 to 2.0 Fils per unit, at which rate the development and sale of the power should be an economical preposition.

The power development possibilities of this general scheme are small. Economical storage requires low dams which result in little and expensive power. The power possibilities of the Fatha dam are much greater than those of the Wadi Tharthar amounting to about 225,000 k.w., but the country's need for power is not believed to justify the selection of the Fatha Project on that account.

c) NAVIGATION. The full development of storage in Iraq and the exhaustive use of the stored water for irrigation would leave no water for navigation in channels not used for irrigation during a large part of the year. This applies particularly to the Lower Tigris and if the important river transport between Basrah and Baghdad is not to be abandoned measures will be necessary to maintain it. This would mean the regulation of all offtakes from the river below Kut and the provision of possibly three regulators with navigation locks. This would permit the maintenance of navigation at all times with the use of very little water. It would greatly improve existing conditions under which navigation is at times difficult or dangerous and subject to interruptions when low supplies are diverted for irrigation. This scheme has not been worked out in detail, but with flood control established the works involved would be small, and the total cost might be about ID 3,000,000. In view of its advantages it might be advisable to take up this Project before it is an absolute necessity and meet the cost by a small tax on the river traffic.

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SUMMARY OF EXPENDITURE. The total expenditure estimated as involved in the full development of the country is summarized below:

FLOOD CONTROL & STORAGE	ID
Habbaniyah	3,375,000
Abu Dibbis	2,000,000
Wadi Tharthar	15,500,000
Diala Dam	2,500,000
Dokan Dam	4,000,000
Total	27,375,000

IRRIGATION DEVELOPMENT	ID
Euphrates	10,500,000
Lesser Zab	4,010,000
IS-Haqi	1,000,000
Nahrwan	7,350,000
Lower Tigris	13,750,000
Total	36,610,000

DRAINAGE	
Old Areas	11,000,000
New Areas	29,200,000
Total	40,200,000
POWER	7,850,000
NAVIGATION	3,000,000
Grand Total	115,035,000

This summary indicates that the total expenditure involved is very high but it must be mentioned that it will be spread over a very long period. The immediate requirements are flood control, improvement of the supplies for the Diala canals and drainage in the old areas. The development of irrigation and power must largely await until a sufficient demand arises to justify their being undertaken. The total area at present served by irrigation in Iraq with lift and flow is about 11,000,000 mesharas. Extension to a further 14,600,000 mesharas is possible but obviously cannot be undertaken by the present population following present methods of cultivation. Even with the introduction of agricultural machinery on an extensive scale, and assuming the natural

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increase in population to be supplemented by immigration to some extent, it is unlikely that full development will be required before the end of the century which would involve an average annual expenditure of about ID 2,000,000 only. Moreover it is anticipated that a large proportion of the capital expenditure will be recovered from the increase in land values resulting from the works, and that revenue sufficient to make the various projects productive will be obtained. The financing of the expenditure is discussed in a separate note.

WORKS REQUIRING TO BE UNDERTAKEN IN THE NEXT TEN YEARS.

As has been stated above the immediate requirements are: Flood Control on both rivers. Supplementary Diala Supplies Drainage of Old Areas. To these may be added a moderate amount of development of new areas to meet the existing demand. The various schemes which should be proceeded with to produce the results are noted below:

(1) Habbaniyah Project Stage I Balance of Expenditure say ID 2,000,000. This will provide control of the Euphrates to 2,500 cumecs and also storage water sufficient for 1,200,000 mesharas of extension.

(2) Wadi Tharthar project Stage I ID 7,000,000. This will in general control the Tigris below Baghdad to 4,000 cumecs. On the rare occasions when floods are exceptionally high, however, the Tigris may rise to 6000 at Baghdad and Diala water might bring the supply below to 8000 or 9000 cumecs.

(3) Gibraltar Dam on Diyla ID 2,500,000. This will reduce the Tigris discharge below Baghdad during high floods by 2,000, to 3,000 cumecs. It will also provide an adequate irrigation supply for the existing Diala Canals and permit extension to 500,000 mesharas.

(4) Drainage in old areas. It is suggested that about ID 500,000 per annum should be devoted to this work which would enable the old areas to be completely equipped in about 20 years. Total for 10 years ID 5,000,000.

(5) Irrigation Development. It is suggested that the following extension should be carried out during the next ten years.

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Euphrates	ID 1,000,000
Nahrwan	500,000
Gharraf	500,000
	ID 2,000,000

In the case of Euphrates, much of the extension would comprise improvement in the supplies of the existing areas for which drains would be provided under (4). The cost including drainage may, therefore, be taken at ID 3.000 per meshara or ID 3,000,000

For the Nahrwan areas the Cassell's Post Barrage would be required costing 450,000

and the cost of canals and drainage may be taken as ID 4.000 per meshara, i.e. 2,000,000

For the Gharraf area the cost may be taken as ID 4.500 per meshara, i.e. 2,250,000

The total cost of these works is thus 24,200,000
or an expenditure of ID 2,420,000 per annum on the average.

The rate of construction of these works can be expedited or slowed down at will. Also further works in the program can be taken up at any time in accordance with the needs of the country.

With regard to power development, it will be noted that the only power project which would be covered by the ten year programme is the Diala Dam. It may, however, be desirable to have Wadi Tharthar power too within this period. Wadi Tharthar power, however, requires the construction of the outlet channel for its development which is not likely to be required for storage purposes until a later date. It would, however, be possible to construct this channel in the interests of power which would of course increase the cost of the power. However, in view of its future value for storage it would, it is thought, be justifiable to charge only a proportion of the cost of this channel to power, thus keeping the power project productive.

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